GOVERNMENT OF INDIA
MINISTRY OF IRRIGATION

REPORT

OF

THE TECHNICAL COMMITTEE TO EXAMINE THE FEASIBILITY OF EASTWARD DIVERSION OF WEST-FLOWING RIVERS OF KERALA AND KARNATAKA

CENTRAL WATER COMMISSION
NEW DELHI
MARCH - 1981

LETTER OF TRANSMITTAL

M.N. Venkatesan,
Chairman, Narmada Control Authority
Formerly Member (Water Resources)
CWC and Chairman, Technical
Committee to examine the feasibility
of eastward diversion of west flowing
rivers of Kerala and Karnataka.

Government of India
Central Water Commission
Sewa Bhawan, R.K.'Puram,
New Delhi-110022.

D.O.No. 1/1/80-WRU-II

Dated the March, 1981.

Dear Sir,

The Government of India (Department of Irrigation) vide their O.M.No. 10/17/76-DW-I dated 16th December 1976 constituted a Technical Committee to examine the feasibilities of eastward diversion of the west flowing rivers of Kerala and Karnataka. The committee could not commence its work till August 1978 in view of the time taken by the Government of Kerala to nominate their representative in the committee.

The committee have held ten meetings and have gone into various aspects in regard to the availability as well as the requirements of water in some of the major west flowing rivers of Kerala and Karnataka. The work of the committee was facilitated by the information supplied by the State Governments of Karnataka, Kerala and Tamil Nadu.

I would like to place in record my appreciations of the cooperation extended by the State Governments and in particular the following officers for making it possible for the committee to finalise its report.

Karnataka

1. Shri B. Subbiah, Special Secretary (Irrigation)
2. Shri R.A. Rao, Chief Engineer, WRDO.
3. Shri S.K. Laxmana, S.E. WRDO, Irrigation Department.
4. Shri S. Raghu Ram, A.E.E. WRDO.

Kerala

1. Shri K. Bhartan, Adviser, Irrigation Projects.
2. Shri Balram, Chief Engineer, Irrigation.

3. Shri N.A. Anandakrishnan, Chief Engineer, General & Project-I.
4. Shri Baby Abraham, Chief Engineer, Projects-II.
5. Shri Ganpathy Iyer, Chief Engineer, Kerala State Elecy. Board.
6. Shri V. Lakshmana Iyer, Chief Engineer, Projects-II.
7. Shri Kunjikrishna Nair, Design Engineer, P.W.D.

Tamil Nadu

1. Shri S. Manavalam, Chief Engineer, Irrigation, P.W.D.
2. Shri S.J. Ambrose, Chief Engineer, Irrigation, P.W.D. (incharge).
3. Shri P.K. Balakrishnan, Special Officer, Inter-State Waters.
4. Shri A. Mohankrishnan, Special Officer, Inter-State Waters.

I would also like to place on record my appreciation for the valuable work done by Shri B.G. Pattegar as in the earlier stage and Shri R.P. Malhotra, Director and Shri R.K. Kaushal, Dy. Director later in convening the meetings.

With kind regards,

Yours sincerely,

Encl: Report:

Shri C.C. Patel,
Secretary to the Govt. of India,
Ministry of Irrigation,
Shram Shakti Bhavan,
New Delhi.

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REPORT OF THE TECHNICAL COMMITTEE TO EXAMINE THE FEASIBILITY OF EASTWARD DIVERSION OF WEST-FLOWING RIVERS OF KERALA AND KARNATAKA.

1.0 INTRODUCTION

1.1 The Irrigation Commission in their report of 1972 have observed that the west-flowing rivers of India (excluding the Tapi and Narmada) are important and constitute a significant source of water. It is further indicated that these rivers carry on an average, nearly 246,700 Mm^3 (200 MAF) of water. However, on account of the very short distance traversed by them from their origin to the coast and the nature of the terrain, the possibilities of utilising these waters for irrigation in these basins are very limited. It may, however, be possible to divert eastward a limited quantity of water from these rivers for irrigation and supply of drinking water in the rain shadow regions.

1.2 Keeping in view the needs of several drought prone areas in Tamil Nadu and Karnataka for irrigation, the Govt. of India constituted in September, 1976, a Technical Committee to examine the possibilites of eastward diversion of the west-flowing rivers, vide their O.M.No.10/17/76-DW-I dated 16th December, 1976. The constitution of the Committee was as below:

1)	Member (WR) Central Water Commission New Delhi.(M.N. Venkatesan)	..	Convenor
2)	Chief Engineer of Kerala	..	Member
3)	Chief Engineer of Tamilnadu	..	Member
4)	Chief Engineer of Karnataka	..	Member
5)	Director, CWC, New Delhi	..	Secretary.

1.2.1 The terms of reference of the Committee as contained in the O.M. of 16th December, 1976 were as follows:

1) Assessment of the water availability in the different west flowing rivers of Kerala and Karnataka at appropriate locations.

2) Assessment of the present utilisation of waters of these rivers in Kerala and Karnataka and new uses already planned and further uses in the foreseeable future both consumptive and non-consumptive like power generation, navigation salinity control including leaching requirements of ports and harbours etc.

3) Formulation of a plan for diversion of surplus waters eastward for irrigation where economically feasible, in view of the availability of local water resources and assessment of its consequential effects in the two States, including the possibility of power generation if water is not diverted.

4) Formulation of a scheme for surveys and investigations for such schemes and assessment of the cost of such investigation and studies.

1.3 The Governmentof Kerala did not agree to these terms of reference.

As a result, after exchange of correspondence the Department of Irrigation, vide their O.M.No.10(17)/76-DW-I dated the 7th October, 1977, issued an amendment to the terms of reference fixed in their O.M. of December, 1976. The following was substituted in place of item (1).

"Assessment of the water availability in the different west flowing rivers (excluding those rivers in respect of which agreements have already been entered into between the Governments of Tamilnadu and Kerala) of Kerala and Karnataka at appropriate locations."

1.4 The convenor of the Committee simultaneously took up the question of representation/nomination of members of the Committee by the concerned State Governments. The Govt. of Karnataka nominated the Chief Engineer, Water Resources Development Organisation as their nominee vide their letter No.PWD-39 LCA 76(Part) dated 29.12.1976. The Government of Tamil Nadu also nominated the Chief Engineer, Irrigation, as their nominee vide their letter No.43774/I Special/76-10 dated 17.1.1977. Subsequently, Government of Tamil Nadu nominated Special Officer, Inter-State Waters vide their letter No.43774/I/Spl/76-34 dated 28.7.1978.

1.4.1 The Government of Kerala, after protracted correspondence, nominated their Adviser, Irrigation Projects, as their nominee vide D.O.No.17016/IWI/76/WNT dated 1.7.1978.

1.5 In view of the initial delays, the work of the Committee could not commence till August, 1978.

The convenor of the Committee, at the outset requested the State Governments of Kerala, Karnataka and Tamil Nadu to supply information regarding availability of water in each basin and its utilisation. They were also requested to supply specific proposals, if any, for diversion of surplus water of west flowing rivers towards the east to meet the demands of irrigation and other needs in drought prone areas.

1.5.1 The 1st meeting of the Committee was held on 2nd August, 1978 at New Delhi. The main basis of discussions at this meeting was the proposals of Tamil Nadu for eastward diversion of water from west flowing rivers of Kerala.

1.5.2. The Government of Tamil Nadu had come up with proposals for 11 diversion schemes aimed at diverting 82 TMC eastward to irrigate about 8.2 lakh acres of land in Tamil Nadu. The outline proposals are indicated in Appendix-1. Index plan showing these proposals is enclosed Drawing No.1. Since Chaliyar basin and Periyar basins were already covered by agreements between Kerala and Tamilnadu, these basins were excluded from the deliberations of the Committee.

Subsequently, Tamil Nadu Govt. submitted an alternative proposal for eastward diversion of west flowing rivers of Kerala namely Achencoil, Kallada, Vamanapuram and Karamana. The proposal envisaged diversion of 31.2 TMC of water from these basins to irrigate areas in Tamil Nadu.

1.5.3 The Kerala representative pointed out that as they have already taken steps to utilise the tail race waters of Sabarigiri, any proposals for diversion, in regard to Pamba basin will affect the power generation and irrigation in

Kerala. In view of this the Committee decided not to consider the Pamba basin and confine its deliberations only to Achencoil, Kallada, Vamanapuram and Karamana basins of Kerala in the first instance.

1.5.4 Karnataka carried out a preliminary study of assessment of water availability and forwarded the same to the Committee. A copy of this study is reproduced in Appendix-2.

The preliminary proposals of Karnataka for utilising water of west flowing rivers for generation of hydel power are given in Appendix-3. On the basis of these studies, the Karnataka Government indicated that there would be no surplus waters available in the west flowing rivers of Karnataka for diversion to the east.

1.5.5 The Kerala Govt. had issued a publication on the "Water Resources of Kerala" which was furnished to the Committee for their consideration. This had been published in 1974 and included the studies carried out by the Kerala Government on water availability based on earlier data. The Committee suggested that water availability should be assessed on more recent data available and an appropriate rainfall run-off relationship should be established to determine the yield from these basins.

1.5.6 The Kerala Government had brought out in their preliminary report of September, 1978, that no surplus water is available from Achencoil, Kallada, Karamana and Vamanapuram basins. They had reported that yield of each basin had been worked out by State authorities on the basis of rainfall run-off relationship established in 1972 (given in Appendix-4).

1.6 Ten meetings of the Committee have been held. The minutes of different meetings held so far were circulated to all the concerned members from time to time and were confirmed with such modification as indicated by the members.

2.0 ASSESSMENT OF WATER AVAILABILITY

2.1 During the first four meetings of the Committee the discussions centered around the preliminary proposals for eastward diversion made by Tamil Nadu. The proposals of Tamil Nadu for diversion were based on "Advance Report on Kerala Water Resources (1958)" and had included some west flowing rivers of Kerala which were already covered by agreements between Governments of Tamil Nadu and Kerala. It was decided at the fifth meeting to restrict the assessment of availability and surplus of water resources in the first instance to the four southern most rivers of Kerala.

2.2 Accordingly, the assessment of water availability has been carried out in respect of Vamanapuram, Achencoil, Kallada and Karamana basins of Kerala.

Likewise in regard to the Karnataka rivers the water availability for Netravathy, Varahi, Mahadayi and Barapole basins have been worked out.

2.3 Water Availability Studies of Kerala Basins:

2.3.1 At the fifth meeting of the Committee it was decided to take up in the first instance, the four Southern-most basins of Kerala namely, Vamanapuram, Achencoil, Kallada and Karamana and Netravati and Barapole basins of Karnataka. The Secretary of the Committee was asked to prepare a detailed appraisal of the hydrology of Vamanapuram basin and estimate the water availability at different elevations based on the data furnished by the Kerala representative on Vamanapuram. The Kerala representative was also requested to make similar studies for the three other rivers namely, Achencoil, Kallada and Karamana. The Committee estimated the availability of water for Vamanapuram basin at different elevations 1000', 750', 500', 250', 50', 0' by establishing suitable rainfall run-off relationship. A copy of the calculations were handed over to the Kerala Engineers in October, 1979. Since the Kerala representative had not carried out the detailed studies for the other three basins, the water availability studies of all these four basins at elevations 250', 50', 0' were carried out by the Secretary to the Committee. The Kerala representatives have gone through the assessment done by the Committee and have agreed with these figures of availability at different contours at the sixth meeting in March, 1980. The details of these four basins alongwith assessment of their water availability at different elevations is given below.

2.3.2 Vamanapuram River

The Vamanapuram river originates from the Chemunji Motai at about + 1860 M. above M.S.L. After traversing a distance of 7 km. it receives the Kalaiparai Aar rising from the Kalakul Motai. At Kallar two more tributaries, the Panni Vadai Aar and the Panmudi Aar join it. After taking water of the upper Chit Aar, and Manjapla river, it flows through Palode and from there at 3 km. downstream the river cascades over a 13 metre Meen Muthi falls. At Choodal, the Chit Aar joins the main river and from here it meanders west-wards till Vamanapuram, where M.C. Road crosses it. Downstream the Kilimanoor Aar joins the main river. The river again flows and falls into the Anjengo Lake at Chirayinkil. The river has a length of 88 km. with a drainage area of 867 sq.km. which lies entirely within Kerala.

The basin has a catchment area of 867 sq.km. and has about 8 raingauge stations in the basin. It is estimated that average rainfall in the basin is 244 cm. (monsoon) above 250' contour and 208 cms. (monsoon) above 0' contour. The river has been gauged at Valayanki and gauge and discharge data from 1972-76 has been used to establish the rainfall runoff relationship. Rainfall data of about thirty years has been used to assess the 75% dependable yields from the basin.

Assessment of water availability as worked out by Tamil Nadu, Kerala and CWC are as follows:

i) Total runoff in TMC as given by Tamil Nadu Government based on advance report of Kerala water resources 1958 is 52.10 TMC (1475.26 Mm^3).

ii) Water availability at different elevations as worked out by Government of Kerala based on the report of Kerala Water Resources-1974 is:

Elevation	C.A.	Yield TMC	Yield Mm^3
Above 250' contour	375 sq.km.	27.15	770
Between 50' and 250' contour	412 sq.km.	16.60	470
Below 50' contour	80 sq.km.	3.00	85
Total:	867 sq.km.	46.75	1325

iii) Water availability at different elevations as worked out by the CWC and assessed at 75% dependability is given below. This has been agreed to by the Kerala Engineers.

Above elevation 250' contour	780 Mm^3	(27.55 TMC)
From elevation 50' to 250' contour	523 "	(18.50 TMC)
Below elevation 50' contour	7 "	(0.25 TMC)
Total:	1310 Mm^3	(46.30 TMC)

Details of the method of assessment of water availability based on rainfall runoff relationship is furnished at Appendix-5.

2.3.3 Achencoil River

Several small streams originating from the Pasukida Mettu, Ranakkl Teri and Rishi Malai at altitudes ranging between 700 M and 160 M above MSL join together to form the Achencoil river. It flows a North Westerly course till Kumbazha and in this portion it is joined by the Kall Aar about 9 km upstream of Torai Forests. From Kumbasha it turns west and flows in that direction for a few miles, then South-Wards for 5 kms and afterwards continues in a Westerly direction till Idannahon. Here it turns Northwest upto Thazhakora and thereafter flows Westwards. At Tharaimukku, the Kuttenperoor canal branches from the main river and joins the Pamba. The river then splits up into several smaller branches and the main branch flows in the North-Westerly direction to join the Pamba river at Veeyapuram.

The length of the river is 128 km. The Kumbazha bridge, the Kaipattoor bridge, the Pandalam bridge, the Kolla Kadavu bridge are some of the important bridges across the river. The total drainage area of the river is 1484 sq.km.

The main river is being gauged at Pandalam and Kollakadava. The average rainfall in the basin is estimated as 248 cm. (monsoon) above 250' contour and 229 cm (monsoon) above 0' contour. Pandalam Gauge and discharge data from

1974 to 1978 has been used to establish the rainfall run-off relationship. There are about 7 rain gauge stations in the whole of the basin. Rainfall data of about 30 years has been used to assess the average yield and 75% dependable yield of the basin.

Assessment of water availability made by Tamilnadu, Kerala and the CWC are given below:

i) Total runoff in TMC as given by Tamilnadu Government based on advance report of Kerala Water Resources 1958 is 76.0 TMC (2152 Mm^3).

ii) Water availability at different elevations as worked out by Government of Kerala based on the report of Kerala Water Resources-1974 is:

Elevation	C.A. in sq.km.	Yield Mm^3	Yield TMC
Above 250' contour	673	1067	37.75
Between 50' & 250' contour	422	680	24.00
Below 50' contour	389	540	19.00
Total:	1484	2287	80.75

iii) Water availability at different elevations as worked out by the C.W.C. and agreed to by Kerala Engineers at 75% dependability is given below:

Elevation	Yield Mm^3	Yield TMC
Above 250' contour	1091	38.54
Between 50' & 250 contour	597	21.10
Below 50' contour	670	23.66
Total:	2358	83.30

Details of the method of assessment of water availability based on rainfall and runoff relationship are given at Appendix-5.

2.3.4 Kallada River

This river is formed by three rivers, the Kulathupuzha, Chendurnil and Kalathuruthy which join together near Parappar by the side of the Trivandrum-Shencottah road.

The Kulathupuzha river in turn is formed by the confluence of Pongumalai Aar which has its origin in Karimalai Kadakkal in Papanasam range at about EL 1524 M, the Sirikala Aar which has its origin in Srikala Hills, at about EL + 1372 M and the Sanklipalam Aar which has its origin in the Ponmudi Ranges at about EL + 1067 M. The Kulathupuzha River flows in a North-Westerly direction till Moyala Mod where it turns and continues to flow in a Northerly direction. It is joined by the Chandurni Aar at Kalangkunnu. The Chandurni Aar originating from the Karimalai Kadakkal and Alwar Kurichi peaks, flows in North-Westerly direction till it joins the Kulathupuzha Aar. The Kalathuruthy Aar which is formed by several streams originating from the Perianuruthi Malai (+ 853 M) Paddikattu Malai (+ 853 M) Kottuvasal Teri (+ 792 M) Pillaiyar Kovil Malai (+ 808 M) and Suvarnagiri Malai (+ 488 M) flows first a South Westerly and then a Westerly course upto Tenmalai where it turns South and joins the Kulathupuzha river at Parappar.

From Parappar, the river flows North-West under the name, the Punalur Aar upto Urkkunnu and then Westwards upto Mukkadavu where it is joined by the Chit Aar, a small stream originating from Kalkunnu. After following North-Westerly course from Mukkadavu upto Pathanapuram, the river turns west and flows in that direction till Enathu, where the M.C. road crosses the river. Thereafter, it flows South-Westerly course till it falls into the Ashtamudi Kayal.

The length of the river is 121 kms. with a drainage area of 1920 sq.kms. The catchment lies entirely within the State.

There are about 9 raingauge stations in catchment area. It is estimated that average rainfall of basin is 254 cm. (monsoon) above 250' and 228 cm. (monsoon) above 0' contour. River discharge data at Enathu discharge site is available for a number of years. Discharge data from 1970-1978 has been used to establish rainfall runoff relationship.

The availability of water is assessed taking into consideration rainfall data of about 30 years. Average and 75% dependable yield is worked out from this data.

Total runoff in TMC as given by Tamilnadu Government based on advance report of Kerala Water Resources 1958 is 76 TMC (2152 Mm^3).

Water availability at different elevations has not been worked out by Government of Kerala in their report of Water Resources - 1974, only the total average yield has been indicated as 80.16 TMC (2268 Mm^3).

Water availability at different elevations as worked out by the CWC and agreed to by Kerala Engineers at 75% dependability is as below:

Elevation	C.A. in sq.km.	Yield Mm^3	Yield TMC
Above 250' contour	829	1179	41.64
Between 50' and 250' contour	608	730	25.78
Below 50' contour	473	560	19.78
Total:	1910	2469	87.20

Details of the method of assessment of water availability based on rainfall and run-off relationship is at Appendix-5.

2.3.5 Karamana River

The Karamana river has its origin in the Chemmunji Mottai and Agastya Malai of the Nedumangad Hills and follows a southerly direction of flow, till it falls into the Arabian sea near Pachallur. The river is formed by the confluence of Kavi Aar, the Attai Aar, the Vaiyapadi Aar and the Thodai Aar. The Killi Aar which joins the Karamana river near Nadakara is its main tributary.

The length of the river is 68 kms. It has a catchment area of 703 sq.km. lying entirely within the State.

There are about 5 raingauge stations in the catchment area. Average annual rainfall of catchment area is 314 cm. (monsoon) above 250' contour and 196 cm. (monsoon) above 0' contour. The river has been gauged at Aryanad and guage-discharge data from 1971-78 has been used to establish rainfall-runoff relationship.

Rainfall data of about 30 years has been used to assess the average and 75% dependable yield of basin.

Total runoff in TMC as given in Tamilnadu Government based on advance report of Kerala Water Resources - 1958 is 38.8 TMC (1078 Mm^3).

Water availability at different elevations as worked out by the Government of Kerala "Water Resources of Kerala-1974" is:

Elevation	C.A. in sq.km.	Yield in Mm^3	Yield TMC
Above 250' contour	243	445.14	15.72
Between 50' and 250' contour	277	309.95	10.95
Below 50' contour	183	165.91	5.86
Total:	703	921.00	32.53

It may be pointed out that while working out the yield Kerala Government used rainfall-runoff relationship of Kallada basin.

Water availability at different elevations as worked out by the CWC and agreed to by Kerala Engineers at 75% dependable yield is given as below:

Elevation	Yield in Mm^3	Yield in T.M.C.
Above 250' contour	535	18.90
Between 50' and 250' contour	34	1.20
Below 50' contour	67	2.40
Total:	636	22.50

Details of the method of assessment of water availability based on rainfall-runoff relationship is at Appendix-5.

Figures of water availability as finalised by the Committee for all the four basins of Kerala is, therefore, as follows:

All Figures in Mm^3

Sl. No.	Basin	Above 250' contour	Between 50' and 250' contour	Below 50' contour	Total
1.	Vamanapuram	780	523	7	1310 (46.3 TMC)
2.	Achencoil	1091	597	670	2358 (83.3 TMC)
3.	Kallada	1179	730	560	2469 (87.2 TMC)
4.	Karamana	535	34	67	636 (22.5 TMC)

The water availability as indicated above is with reference to the contours on the lines given by Kerala Govt. in their report on water Resources 1974 and not at isolated points along the course of the river.

2.4 Water availability studies of Karnataka Rivers

2.4.1 Karnataka Government were requested to make a detailed analysis of available water resources in the west flowing rivers (1st and 2nd meeting). Karnataka Govt. supplied a general note on the subject in May, 1980, indicating the availability of water based on empirical formula i.e. Inglis formula only. They were asked to reassess the same by more rational methods. Calculations of Vamanapuram basin of Kerala carried out by C.W.C. were furnished to the Karnataka Engineers with a request to establish rainfall-runoff relationship for their basins on similar lines to assess the yield at different elevations. This has been done in the case of Varahi where data is available.

In the light of the decision at the fifth meeting of the Committee, the Karnataka representative has furnished in October, 1980 the yields for the various west flowing rivers of Karnataka.

2.4.2 Netravathy Basin

Netravathy river rises in Kudramukh hill range near Samse of western ghats in Chickmaglur district and flows for a length of 92 km. (57 miles) in Dakshina Kanada District before joining the Arabian Sea near Mangalore city. The altitude where the river rises is about 915 metre (3000 ft.) and within a short distance of about 5.6 km. (3.5 miles), the level falls to about 122 m (400 ft.). The approximate slope of the river in this reach is about 1 in 7.

The catchment area of the river basin upto sea is 3222 sq.km. (1244 sq. miles) with an average rainfall of 396 cm. (156") per annum. The yield according to Inglis Ghat formula is 9940 Mm^3 (351 TMC).

2.4.3 Barapole Basin

Barapole river in Coorg District has three main tributaries Kakttuhole, Konganahole and Kali Thodu. The stream which is Barapole after confluence of the above three tributaries at Kuttiyala flows in a hilly tract in upper reach in Karnataka, in the flat low-lying land near the State border and in a comparative flatter country further down before finally joining the sea near Chiraka.

The yield has been given by the State Govt. at the proposed Kutiyala Dam site. The catchment area at the dam site is 260.30 sq.km. (100 sq. miles) and the average yield is assessed at 622.97 Mm^3 (22 TMC).

Total yield of the basin as per Inglis formula from catchment area of 560 sq.km. as estimated by State Government comes to 45 TMC.

2.4.4 Varahi Basin

Varahi river originates near Guddakoppa village in Shimoga District at an EL of about 760 M in hilly and forest regions having an annual rainfall of 3800 to 4000 mm. This river is called Naldi river in the lower reaches and joins the Arabian sea near Coondapoor. The catchment area upto the sea is 760 sq.km. and the yield according to Inglis Ghat formulae is estimated as 80 TMC for an annual rainfall of 3800 mm. Karnataka Government estimated the yield at EL 305 M.(1000 ft.) according to Inglis formula as 21.95 TMC from a catchment area of 203 sq.km. against 21.5 TMC actual observed at Mani from a catchment area of 160 sq.km. The Karnataka Government established rainfall-runoff relationship based on data collected at Haladi i.e. at EL 50' for about 8 to 9 years. The average yield from this basin is estimated as 94 TMC against the actual observed yield varying from 77.6 to 106 TMC.

2.4.5 A Table showing the catchment area and average yield of each basin as supplied by Karnataka is enclosed in Appendix-2.

2.5 Ground Water Availability

2.5.1 Kerala

The question of use of ground water was taken up at the 3rd meeting of the Committee. The Chairman of the Committee was of the view that possibilities to meet part of the requirements for consumptive use in irrigation, domestic and industrial water supply etc. from ground water should be explored.

2.5.2 The Government of Kerala have been holding the view that the aquifers in the State are poor in general and that the ground water potential would therefore, be relatively meagre. The Committee had discussed the question of availability of ground water in the subsequent meetings and the report of the Central Ground Water Board - April, 1978, covering the four river basins under consideration was studied. As per this report the ground water potential available in different districts associated with these four river basins of Kerala are as follows:

District	Total rechargeable area in sq.km.	Total water potential in Mm^3
Trivandrum	1317	181.30
Allepy	1599	828.84
Quilon	2827	572.66
		1582.80
	Say	1583 Mm^3

With respect to the report of C.G.W.B. the observation of the Kerala representative were as below:

1) Only very preliminary investigations are done by the Central Ground Water Board in Kerala.

2) The quantity of ground water, is assessed from an assumed percentage of rainfall as infiltration and not based on data regarding the aquifers, the specific yield etc

In view of the above the figures quoted by CGWB were not acceptable to the Kerala representative. The Kerala representative had pointed out that the Ground Water in Kerala is reappearing in the river as base flow in the summer months and two quantities cannot be separately taken. Chairman and other members had explained to the Kerala representative that these are always taken as additives in water balance studies of any river basin.

The approximate ground water potential worked out by the C.W.C. based on the report of Central Ground Water Board for the rechargeable area extending from elevation 0' to 250' in these four basins is as below:

Sl. No.	Basin	Ground Water Potential (0 to 250' only)
1.	Vamanapuram	75.64 Mm^3
2.	Achencoil	271.65 "
3.	Karamana	63.32 "
4.	Kallada	218.98 "
	Total:	629.59 "

2.5.3 Karnataka

The Karnataka Government was requested to supply information regarding available ground water potential in the State. They have supplied the information to the Committee as given in the following table 2.5.3.

2.6 Utilisable Yield

2.6.1 In general taking into consideration topography of the State of Kerala each basin can be divided into three zones.

i) Flat terrain near the coast below 15 M (50 ft. contour).

ii) Rugged and rolling mid land region between 15M (50') and 75M (250') contour.

iii) Steep mountaineous terrain above 75 M (250') contour.

The above division has been worked out on the lines the report on "Water Resources of Kerala - 1974".

2.6.2 As indicated above the area above EL 250' is mostly mountaineous and the yield from this area could be stored and utilised in the basin or diverted outside. All the members of the Committee except the representative from Kerala were of the view that the entire yield above EL 250' can be usefully utilised. The utilisable yield from this area has therefore been taken as 100%. **Area** from 50 ft. to 250 ft. contour is rugged and rolling mid land region. Cultivable area is located in this portion and the yield can be utilised for meeting demands of irrigation, industrial and domestic needs. It was felt by the committee that at least 75% of the yield from this area could be utilised or diverted. The area from EL 50' and below is a flat coastal belt. The committee was of the view that the yield in this reach can not be put to any effective use. In view of this utilisable yield from this reach is taken as zero.

2.6.3 The Kerala representative was however of the view that only 85% of the water above 250' contour and 50% between 50'

Table 2.5.3

GROUND WATER POTENTIAL WEST FLOWING RIVERS OF KARNATAKA

Sl. No.	Name of Basin	Area in Km^2	% of gross rainfall contribution to recharge	Gross recharge Mm^3	No. of energised wells	No. of non-energised wells	Total no. of wells	Discharge in Mm^3	% utilisation
1.	**Netravathy**	7426	3	769	10431	7346	17777	147	19
2.	Sita	1915	3	198	4970	4470	9440	66	33
3.	**Haldi/Varahi**	2115	3	219	1790	2912	4702	23	11
4.	Swarna	3468	3	149	824	5667	6491	45	30
5.	Aghanashini	5402	3	233	1089	7102	8191	48	21
6.	Kali	5888	3	253	478	4550	5028	32	13

contour to 250' contour could be taken as utilisable. To work out an index of possible percentage utilisation of available supplies at different elevations, the Kerala Engineers were requested to collect information on effective storages of existing reservoirs/storages under construction and those contemplated in the ultimate stage of development in each basin. Since this information was not made available, the committee has covered in this study both the view points in respect of utilisable yield.

2.6.4 The utilisable yield has been estimated as per both the assumptions indicated above.

Table 2.6.4

UTILISABLE YIELD

All figures in Mm^3

Sl. No.	Basin	Above EL 250' contour	Between 50' & 250' contour	Below 50' contour	Total
	As per Committee's Assumption				
		(100%)	(75%)	(0%)	
1.	Vamanapuram	780	392	0	1172
2.	Achencoil	1091	448	0	1539
3.	Kallada	1179	548	0	1727
4.	Karamana	535	26	0	561
	Total:	3585	1414	0	4999
	As per Kerala's Assumption				
		(85%)	(50%)		
1.	Vamanapuram	663	262	0	925
2.	Achencoil	927	299	0	1226
3.	Kallada	1002	365	0	1367
4.	Karamana	455	17	0	472
	Total	3047	943	0	3990

2.7 Regeneration flow

The question of water available from regeneration came up at the fourth meeting. After detailed discussions it was agreed at the fourth and fifth meetings that in view of the terrain of the country in both Kerala and Karnataka, 15% of water applied to wet crops should be taken as regeneration flow. Accordingly this has been taken into consideration while assessing the total availability.

3.0 WATER REQUIREMENTS

3.01 The 2nd term of reference covers the assessment of present utilisation, new uses already planned and further uses in the foreseeable future both non-consumptive and consumptive like power generation, navigation, drinking and industrial requirements and salinity control including leaching requirements of ports and harbours.

This aspect was discussed at the first meeting and it was decided that for the river basins from which reasonable possibilities of eastward diversion exist, the details of the utilisation at present and in future should be supplied by the Govts. of Kerala and Karnataka.

3.02 Information as supplied by the State Governments on the water requirements of the basins under study is presented and discussed below:

Kerala

3.1 Kerala is essentially an agriculture State and about 70 to 80% of the population of State depends on agriculture for their livelihood. The main food crops grown in the State are paddy, pulses, tapioca, banana and vegetables etc. while the cash crops include rubber, coffee, tea, pepper, coconut, arecanut, etc.

3.1.1 Paddy, the main cereal crop of the State is grown in wet lands which are mostly located in central and coastal areas. Sugarcane is cultivated in higher reaches of wet lands in some river basins.

Coconut, tapioca, peas, bananas, pepper and vegetables are grown in the garden lands.

3.1.2 At present rainfall is the main source of water for the crops and the State has a fairly high rainfall of about 3085 mm. per annum. It is estimated that 90% of the rainfall occurs during south west and north east monsoon period which is mainly from June to November. During June and July the intensity of rainfall is very high while from December to May very little water is available from rainfall for the crops. As a result of this uneven distribution of rainfall, the necessity of irrigation from storages is keenly felt.

3.1.3 The paddy crop pattern adopted in Kerala is:

i) Viruppu crop which roughly coincides with south-west monsoon.

ii) Mundakan crop which roughly coincides with north-east monsoon.

iii) Punjha crop which is cultivated in summer months.

Viruppu crop/Autumn crop is sown in April and harvested in August. Due to heavy rainfall and for avoiding flooding the crop is grown in higher areas. Second crop is transplanted variety and cultivation is commenced in September and harvested in December. The third crop viz. Punjha cultivation starts in January and is harvested in April.

3.1.4 Water requirements for different purposes in the four basins of Kerala are discussed below:

3.1.5 Irrigation

(a) Paddy crops

The Kerala Government had initially assumed the delta for the three paddy crops as 3.43 metres. At the sixth meeting they indicated that they have reviewed the same and it works to 3.9 metres.

In this connection it may be pointed out that in the following projects of Kerala State the following deltas have been adopted for the three paddy crops:

Name of Project	Delta in metre
Kanharipuzha	1.83
Idamalayar	1.82
Chalakudy	1.98
Vamanapuram	2.99

Further the Government of Kerala and Govt. of India

(Department of Agriculture) have recently submitted an appraisal report for the Kallada Project for loan assistance from the World Bank. In this report the crop pattern adopted is as below:

1. Viruppu crop of paddy in Kharif.
2. Mundakan crop of paddy in Rabi and
3. A mixed crop in the summer season with no or very little paddy.

It was pointed by other members of the committee to the Kerala representative that the cropping pattern indicated above by Govt. of Kerala to the World Bank may be adopted for working out irrigation requirements for the three other basins which are adjacent to the Kallada basin. Also it was felt by the other committee members that the delta adopted for working out water requirement should be the same as indicated in the appraisal report of Kallada viz. 1.81 M. It was pointed out by the Kerala representative that although they have indicated a different cropping pattern in the report to the World Bank, it will be necessary to go in for three paddy crops in Kerala in view of the acute shortage of rice, the staple food.

The other committee members did not agree with the views of the Kerala representative as it would be harmful from an agronomical point of view in respect of productivity, soil fertility etc. to have three crops of paddy. The Kerala representative further stated that the delta of 1.81 M has been arrived at in the report on the basis of 75% efficiency which is difficult to achieve. While this argument was not acceptable to the committee, they were inclined to a higher delta of 2.61 M indicated by the Kerala Govt. at the 10th meeting held on 25th and 26th Feb., 1981 purely for the purposes of assessing the water requirements for irrigation. The Kerala representative however desired that the irrigation water requirement may be considered as indicated by them viz. 3.839 M. for three paddy crops as this figure had been furnished by their Agricultural Department. The water requirements for irrigation in these four basins of Kerala have therefore been worked out both considering the delta given by Kerala viz. 3.839 M and the delta of

2.61 M agreed to by the committee for the purpose of working out the water requirements for arriving at the water balance only.

3.1.6 Garden land and dry crops:

The Government of Kerala had initially given a delta of 0.61 metre for garden land and dry crops in the area. At the sixth meeting of the committee the Kerala representative indicated that the delta for garden crops should be 1.3 metres as indicated by their agriculture department. In support of this delta of 1.30 M for garden and dry crops the representative of Kerala had referred to the World Bank report of Kallada (July 1980). This report however indicates delta for dry and garden crops varying from 269 mm to 675 mm depending on the crop adopted. It was therefore decided by the other members of the committee that delta of 610 mm may be taken for the dry crops and garden land consisting essentially of coconuts with tapioca or pepper.

The Kerala representative had also pointed out that during the preparation of the volume on water resources of Kerala 1974, it was proposed to irrigate only 50% of the available garden land as it was found that adequate water was not available. Later, they have indicated that they would like to irrigate the entire area as garden and dry crops in the new projects and suitable provision should be made to revise the irrigation requirements for garden land and dry crops. It was explained to the Kerala representative that it is not possible to bring whole area under garden land considering the need for sunshine and the density of growth of trees. It was also pointed out to them that while clearing the Kallada project, the planning commission has indicated only 53% of the area as garden land. In view of the above the other members of the committee decided that only 50% of land should be taken as area under garden land with a delta of 610 mm.

3.1.7 The Irrigation water requirements for the above deltas for paddy and garden lands for these four basins are given in the following table 3.1.7.

Table 3.1.7

KERALA BASINS IRRIGATION NEEDS

All figures in Mm^3

Basin		3 paddy crops delta 2.61 M 50% G. Land 0.61 M.	3 paddy crops delta 3.839 M 100% G. Land 1.30 M.
Vamanapuram	15000 ha		
Wet Land		632	1599
50% G. Land	39350 "		
100% G. Land	78700 "		
Achencoil	20400 ha		
Wet Land		701	1504
50% G. Land	27750 "		
100% G. Land	55500 "		
Kallada	25000 ha		
West Land		980	2351
50% G. Land	53500 "		
100% G. Land	107000 "		
Karamana	10000 ha		
Wet Land		384	907
50% G. Land	20100 "		
100% G. Land	40200 "		
	Total:	2697	6361

3.2 Domestic Water Requirement

3.2.1 The Government of Kerala in their 1974 report of Kerala Water Resources assessed the domestic water requirements at 160 litres/head per day. During the earlier meetings also they desired that their demand for this should be taken as 160 litres per head per day for the whole of population i.e. rural as well as urban.

However, the committee was of the view that 160 litres per head per day should be for the urban population and 80 litres per head per day should be for the rural population as 50% of the requirements of the rural population would be met from ground/surface water.

At the sixth meeting of the committee the Kerala representative desired that the domestic water requirements should be assessed at 300 litres per head per day for the whole of the population of the State. Since this high figure is not prevalent anywhere in the country, it was decided to consult Central Public Health Engineering Department.

3.2.2 The opinion of Central Public Health & Engineering Deptt. was sought, the norms were indicated as follows for the urban population:

1) For communities with population up to 10,000
   = 70 to 100 litres/head/day.
2) Population between 10,000 to 50,000
   = 100 to 120 litres/head/day
3) Above 50,000
   = 125 to 200 litres/head/day.

A copy of the letter of Central Public Health Department was also sent to Kerala Govt. for adopting these norms and to revise their requirements accordingly.

Taking into consideration recommendations/norms prescribed by Central Public Health Department the committee have therefore worked out domestic needs on the projected population for the year 2021 AD assuming 50% of total population as urban population at the following average rates.

a) 160 litres per head per day (urban)
b) 80 litres per head per day (rural)

The Kerala representatives at the tenth meeting agreed to the quantity at 160 litres/head/day but stated that this should apply uniformly to the entire population. This was not agreed to by the other committee members.

The requirements of domestic needs of the four basins of Kerala worked out on the above lines are indicated in the following table 3.2.2.

3.3 Industrial Water Requirement

3.3.1 Industrial needs of water as assumed by Government of Kerala are given below. No details have however been supplied by the State Govt. as to how they arrived at these figures:

1)	Vamanapuram	45 Mm^3
2)	Achencoil	45 "
3)	Kallada	400 "
4)	Karamana	45 "

It was pointed out at the sixth meeting of the committee that Kerala Government should furnish more realistic figures taking into account their experience of existing and proposed small scale and large scale industries. The Kerala respresentatives had also indicated that the above requirements have been assessed after considering the requirements of paper industry as well as rubber based industries. The committee desired that the industrial needs of different basins be got checked with the Kerala Industries Department and a final figure supplied to the committee. The committee was also of the view that the industrial requirement for Kallada basin appeared to be very much on the higher side. The Kerala representative, therefore was requested to re-examine the same.

3.3.2 The Kerala representative had given a revised industrial requirement as 245 Mm^3 and the requirement for future coir and handloom industry has been indicated as an additional 245Mm^3. While the estimated figure of 245 Mm^3 as given by Kerala has been accepted, the 100% extra provision for future coir and handloom industry was not agreed to by other members of the committee. Industrial water requirements of 245 Mm^3 has therefore been distributed in the four river basins as below:

Karamana	45 Mm^3
Vamanapuram	50 Mm^3

Table 3.2.2

DOMESTIC NEEDS (KERALA BASINS)

Sl. No.	Basin	Population Projection for the year 2021 AD assuming 50% urban (in lakhs)			As per Committees Recommendation					As per Kerala's Suggestion (Mm^3)
					Rate-lit/hd/day		Requirement (Mm^3)			
		Urban	Rural	Total	Urban	Rural	Urban	Rural	Total	@ 160 lit. for both urban and rural
1.	Vamanapuram	14.50	14.50	29.00	160	80	84.70	42.35	127	169
2.	Achencoil	3.25	3.25	6.50	160	80	19.00	9.50	29	38
3.	Kallada	20.88	20.88	41.76	160	80	122.00	61.00	183	245
4.	Karamana	9.11	9.11	18.22	160	80	53.20	26.60	80	106

Kallada	100 Mm^3
Achencoil	50 Mm^3
Total:	245 Mm^3

This requirement has been included in the studies carried out to determine the water budgeting of the different basins vide Appendix 8. In Appendix 9, the requirements of industrial use has been included as indicated by the Govt. of Kerala vide their No.PIDO-III/T/45536/76 dated 26.11.80.

3.4 Requirement for salinity control

3.4.1 The Kerala representatives had indicated during the course of discussions that the areas in and around the outfall of the rivers in the coastal regions are below mean sea level resulting in salinity intrusion from the sea specially when the fresh water flows in the rivers dwindle. According to the Kerala representative, detailed studies had been carried out by the Kerala Government on the Periyar river to determine the minimum flow of fresh water to be maintained in the river to keep down the salinity below the prescribed maximum. In the experiment carried out by the Kerala Government three years data was collected and analysed with a view to establish a relationship between the discharge in the river and the salinity below 50 ppm at a fixed point. The relationship in case of Periyar fairly confirms with theoritical values obtained from the formula

$$Q = 15 A\sqrt{hi\,\frac{\Delta P}{P}} \quad \text{where}$$

Q = discharge of fresh water required in M^3 per sec.

A = Area of cross section of the water course at the interface in square metre.

h = depth of water at the interface in metres

i = slope of the interface between fresh- and salt water

ΔP = difference in densities between fresh water and salt water

P = density of fresh water in gms. per cc.

The requirements of fresh water for combating the salinity were accordingly indicated by the Kerala representative and are at Appendix 6.

3.4.2 It was pointed out by the Chairman and other members of the committee that it was not customary to make any special provision for salinity control. Even if some provision is made it will have to be in the form of storage as the release for combating salinity will necessarily have to be in the low flow season. This would make the project not viable. Also it was pointed out that the quantity of fresh water indicated is very much on the high side. e.g. the requirements shown in the Kallada basin for salinity control is as much as eight times of the lean weather flow in that basin. It was therefore proposed that the quantity of fresh water to be allowed should be only equal to the average lean weather flow in the river. The Kerala representative did not agree with this view point.

After considerable discussion it was decided by the other members of the committee that on the assumption that the lean weather flow was of the order of 100 cusecs in the rivers Vamanapuram, Kallada and Achencoil and 50 cusecs in Karamana river, an additional flow equal to lean flow could be provided for salinity control. This means that for the six months lean flow period a quantity of 90 Mm^3 (approximate) will be required for salinity in Vamanapuram, Kallada, Achencoil basins and about 45 Mm^3 in Karamana basins.

3.5 Karnataka

3.5.1 The Govt. of Karnataka was requested to furnish their requirements of water as required under the 2nd term of refererence. Earlier they had furnished their preliminary proposals for generation of Hydel Power and for irrigating an additional area of 5 lakhs ha. The details of the proposals had not been furnished. They had also indicated that there is no surplus water for diversion from west to east. The Govt. of Karnataka later supplied information in regard to water requirements of Mahadayi, Netravathy, Barapole, and Varahi basins which is discussed below:

3.6 Proposals of Karnataka Government

3.6.1 The technical committee had been requesting the

Karnataka representatives to supply information on their diversion proposals of the west flowing rivers for possible use in the East of the Western Ghats in the State of Karnataka. The State Government had sent a note in December. 1978 indicating average yields, proposed Hydro-power potential and water requirements for the power potential. According to this note, overall average yield for all the West flowing rivers of Karnataka is estimated at 2030 TMC (57481 Mm^3) as given at Appendix 2. In this note they had also indicated that about 7 lakh ha. of culturable area is available and only 1.5 lakh ha. are under irrigation and for the balance 5.5 lakh ha, irrigation facilities have yet to be created.

3.6.2 The Government of Karnataka were of the view that the entire water potential available in the major west flowing rivers would be utilised for development of hydro power which is being planned by the Mysore Power Corporation. They had indicated that there will not be any water available from Netravathy or from any stream North of Netravathy for diversion outside the basin of west flowing rivers of Karnataka.

A preliminary study was made regarding diversion of surplus water from West flowing rivers to East for irrigating drought-prone areas of Karnataka. This was discussed with the representative of Karnataka.

In the light of the above the technical committee requested the Government of Karnataka to supply information for each basin of the west flowing rivers in Karnataka to examine the feasibility of diversion of surplus water to the East for irrigation of deficit areas in Karnataka.

A note in respect of Netravathy, Varahi and Barapole basins only was supplied by the Karnataka representative to the committee on 22nd October 1980 during the 7th meeting of the Committee.

3.6.3 The information as supplied by State Government on various occassions and information collected from the Mysore Power Corporation is discussed below:

3.6.4 Studies made by the committee indicate that the rivers Varahi, Netravathy, Aghanasaini, Dedthi, Mahadayi and Barapole offer possibilities of diversion of surplus water towards East for irrigating drought-prone areas on the lee-ward side of the Western Ghats in Karnataka. It was agreed at the 5th meeting of the Committee that Netravathi and Barapole only were to be examined in the first instance. Since some information was available for the Varahi and Mahadayi basins, these have also been examined by the Committee.

3.6.5 Mahadayi Basin

Based on the information collected from Mysore Power Corporation, studies for possible diversion towards East in respect of Mahadayi basin were carried out which are at Appendix 7.

The Mysore Power Corporation have a proposal of generation of 140 megawatt of hydro power by constructing two dams on the river Mahadayi. The study carried out, based on topo sheets indicate that the lower dam can be shifted about 5 km. downstream for better storage without affecting the available head for generation of power. This also reduces the length of the tunnel considerably. On the basis of available yield data as supplied by Karnataka, this alternative can offer a surplus of about 13 TMC (360 Mm^3) which could be diverted to Malaprabha basin for irrigating areas to the tune of about 80,000 ha. (dry irrigation) in Belgaum and Dharwar districts of Karnataka.

3.6.6 At the Seventh meeting of the Committee, the Karnataka representative was requested to get similar studies made for Aghanashini, Bedthi, Varahi, Swarna, Sitanadi, Savehakklu and Chakkra basins to assess the surplus water available from each of the basins. It was also pointed out that the water available, water requirement for irrigation, domestic, industry and other needs should be brought out clearly in the studies requested. It is reported by Karnataka, that Savehakklu and Chakra have been tapped for augmenting supplies to Linganmakki reservoir and Sita and Swarna being at lower levels as such do not have any scope for diversion to East.

3.6.7 Netravathy Basin

The Government of Karnataka sent a note in October

1980 indicating their requirements in Netravathy, Barapole and Varahi basins. The irrigation requirement in Netravathy basin was given as 8.4 TMC to irrigate areas lying between 12 M to 85 M (40 ft. to 270 ft.)

It was proposed to construct a reservoir across Naria hole, a tributary of Netravathy. It was estimated that there could be an yield of 28.06 TMC (811 Mm^3) from a catchment area of 274 sq. km. It was proposed to irrigate about 4254 ha. (10500 acres) and to meet the demand of drinking water of Mangalore city.

As per the recent modified proposals, the Govt. of Karnataka have indicated that it is possible to divert 11.25 TMC of water by gravity and 12.75 TMC by pumping to the east for meeting the demands of irrigation in areas in Karnataka to the East. However such diversions will reduce the power potential in the basin.

3.6.8 Barapole

As indicated earlier the yield from the catchment of 560 sq.km. in Karnataka is estimated by State Government as 45 TMC.

The culturable area in this basin has been estimated at 20000 ha. out of which 773 ha. is presently under irrigation. It is intended to bring 10000 ha. under irrigation and the water requirement is estimated as 15 TMC.

The requirement of power is indicated at 22 TMC for an installed capacity of 180 MW. The State Govt. has intimated that they cannot utilise the tail race waters as the power house is located at the Interstate border. The tail race water can therefore be utilised by the lower state i.e. Kerala for irrigation, domestic and industrial needs etc. Karnataka Govt. have intimated that they were examining possibility of diversion of surplus water to east and studies indicate that there is possibility of diverting 10.9 TMC to east out of total availability of 45 TMC. The State Govt. have also indicated that this meagre diversion will not affect irrigation in Kerala. Also this diversion is at the cost of power development in the basin.

There is a possibility of diverting 5.5 TMC from Kongon hole tributary as well. This proposal would however mean submergence of valuable forest areas and coffee gardens which will have to be looked into by the State Govt.

Regarding Barapole basin the Kerala representative had been of the view that any diversion of water away from the Barapole river should be done only after meeting the committed requirements of Kerala in the Barapole basin. The Chairman of the committee had desired that this should be settled bilaterally between the two states.

3.6.9 Varahi Basin

The Karnataka Govt. has indicated their irrigation demand as 13.65 TMC from this basin out of an yield of 94 TMC of the basin. They have proposed to irrigate 6070 ha. (15000 acres) of sugarcane, 9632 ha. (23750 acres) of paddy and 9632 ha (23750 acres) of dry crops. They intend to use 21.5 TMC of water for generation of hydel power of 239 M.W. The tail race discharge is expected to be of the order of 1100 cfs.

3.6.10 The State Govt. had a proposal of diverting 25 TMC of Varahi water to the east to irrigate 1.08 lakh ha. (2.68 lakh acres) in the Tungabhadra Valley. But this involved submersion of lands at storage dam site as well as at Tunga anicut. This proposal was therefore shelved and the State Govt. now intends to utilise the water for power generation only.

However, the committee has indicated to the State authorities to explore the feasibility of diversion of 25 TMC of water to the east to irrigate about 2.5 lakh acres as this water is likely to go to waste to the sea. The committee has suggested to the Government of Karnataka that Hydel power may be produced from other two tributaries of Varahi to meet the demands of power and feasiblity of diversion from main dam towards East for irrigating drought areas in Karnataka may be examined. Chief Engineer, Karnataka indicated that the power project is under execution and if any surplus is available for diversion it is at lower levels.

3.7 Domestic, Industrial and Salinity Requirements

The Govt. of Karnataka has not supplied any information so far in respect of industrial and salinity needs. These have therefore not been discussed in this report. In regard to domestic requirements, Karnataka had subsequently indicated a need of 300 litres per head per day which was considered by the committee to be on the higher side. It was decided to adopt domestic needs as per norms recommended by the Central Public Health Engineering Department.

3.8 The above studies indicate that it may be possible to irrigate the drought prone areas in Karnataka as below after diversion of surplus water to east from these four basins.

Basin	Surplus water to be diverted	Proposed area to be irrigated in drought prone area
Netravathi	24 TMC	More than 2.0 lakh acres
Barapole	10.9 TMC	More than 50,000 acres
Varahi	*25 TMC	More than 2.0 lakh acres
Mahadayi	*13 TMC	2.0 lakh acres
Total: Say 73.0 TMC	72.9 TMC	More than 6.5 lakh acres

* Subject to investigations.

3.9 Karnataka has also indicated possibility of diversion of 5.5 TMC from Aghanashini basin to East.

Studies were also carried out by the committee in respect of Bedthi and Aghanashini basins. It was pointed out to the Karnataka representative that 22 to 25 TMC could be diverted from Bedthi to the east by suitably shifting the location of proposed dam without affecting the power potential. Similarly 25 TMC could be diverted from Aghanashini for meeting irrigation/drinking needs of drought areas in Karnataka. The Committee have requested the Karnataka Govt. to examine this aspect also.

4.0 TAMIL NADU PROPOSALS:

4.1 The Government of Tamil Nadu have indicated that certain areas of Coimbatore, Ramanathapuram, Madurai and Tirunelveli Districts are classified as drought affected zones as they receive annual rainfall less than 90 cm. and area irrigated with reference to cultivable area is less than 30%. They have consequently pleaded for Eastward diversion of West flowing rivers of Kerala. Their plea is supported by the report of the Irrigation Commission wherein the possibility of diversion of west flowing rivers towards East has been indicated. The availability of surplus in west flowing rivers as worked out by Tamil Nadu is based on the estimates of Government of Kerala made in their "Advance Report on Kerala Water Resources" (1958) where the overall yield was worked out as 2560 TMC and surplus quantity as 1430 TMC.

4.2 1st Proposal:

The Government of Tamil Nadu have sent two proposals for such diversion. In the earlier one they have come up with a proposal for 11 diversion schemes aimed at diverting about 82 TMC of water eastward to irrigate about 8.2 lakh acres of land in Tamil Nadu. The outline proposals are indicated below:

1st Diversion Proposals by Tamil Nadu Govt.

Sl. No.	Name of the Basin	Total Catchment area sq.m.	Total runoff in the basin TMC	Surplus in the basin TMC	Quantity that can be diverted to east TMC	Ayacut benefited areas in lakhs acres	Districts of Tamil Nadu Benefited by the Diversion
1	2	3	4	5	6	7	8
	Chaliyar Basin						
1.	Pandiyar-Punnapuzha Mayur Scheme	1085*	185.00*	159.3*	14.0	1.40	Coimbatore
2.	Cholathipuzha				3.0	0.30	Coimbatore
3.	Bangihalla				0.5	0.05	Coimbatore

1	2	3	4	5	6	7	8
	Periyar Basin						
4.	Anamalayar				2.5	0.25	Coimbatore
5.	Idukki-(diverting part of runoff of the Periyar)	1736@	378.2@	321.0@	10.0	1.00	Madurai & Ramanathapuram
6.	Kallar Diversion Dam				2.0	0.20	Madurai
7.	Pambar (Sabarigiri)	763	222.8	190.5	26.0	2.60	Ramanathapuram and Tiruneveli
8.	Achankoilar	446	76.00	62.9	9.0	0.90	Tirunelveli
9.	Kallada River	600	76.00	43.7			
10.	Attinkal (Vamanapuram)	336	52.10	42.2	15.0	1.50	Tirunelveli
11.	Karmana Ar.	250	38.8	28.4			
	Total:	5216	1028.9	848.0	82.0	8.20	

* pertains to Chaliyar basin as a whole.

@ Pertains to Periyar basin as a whole.

A plan showing the proposals is appended vide drawing 1. Since the Chaliyar and Periyar river basins are already covered by agreement between Kerala and Tamil Nadu under 1st term of reference of the committee, these were excluded from the delibrations of the committee. Further, diversion from Pamba has been temporarily deferred as some more studies were required to be carried out by the Kerala Govt. regarding the diversion of Tailrace waters of Sabarigiri, at least during June to October.

4.3 2nd Proposal:

In the subsequent proposal they have aimed at diversion of waters from Achencoil, Kallada, Vamanapuram and Karmana Basins. The proposal envisages a series of inter-connected dams together with a contour Canal 6.5 miles long (10.4 km). The proposal envisages utilisation of 31.2 TMC of water from Kerala. A brief outline of the proposals is as below:

2nd diversion proposal of surplus waters of West flowing rivers of Kerala as proposed by Tamil Nadu Government.

(All figures are approximate)

Description	Units	Achencoil AR		Kallada AR		Karamana AR		
		Dam across Kalar	Dam across Achencoil AR	Dam across Tributary Punalar AR	Main dam across Chendurani AR	Dam across Kalathupuzha	Dam across Attinkal (Vamanapuram)	Dam across Karamana AR
Catchment area	sq. miles	25	18	27	36	22	16	12
Yield at dam site	TMC	5.0	3.6	5.4	7.2	4.4	3.2	2.4
Quantity proposed for diversion (Cumulative)	TMC	5.0	8.6	14.0	31.2	10.0	5.6	2.4

Total quantity of water to be diverted 14.0+7.2+10.0 = 31.2 TMC

4.4 A perusal of the two proposals would reveal that the diversion from the four basins i.e. Achencoil, Kallada, Vamanapuram & Karmana in the second proposal is 31.2 TMC against 24 TMC of the first proposal.

4.4.1 Government of Kerala's Views on the proposals of Tamil Nadu:

The Govt. of Kerala have stated that the annual yield figures which are quoted by Tamil Nadu in their diversion proposal have been extracted from "Advance report on Kerala water resources" published in 1958 which were based on meagre data of river flows, whereas by 1972 about 10 to 12 years of observed stream flow data was available. According to them the revised yield figures are presented in "Water Resources of Kerala" brought out by Govt. of Kerala in the year 1974.

Although in "Water Resources of Kerala" (1974), it has been mentioned that the yield figures worked out are for 75% dependability, the Kerala Government have subsequently indicated at the 5th meeting that the figures indicated in the report are average annual yields and not 75% dependable yields. This was not agreed to by the committee.

4.4.2 Third Proposal:

At the 2nd meeting of the Committee, the following alternatives of transferring water eastward, subject to availability of surplus water, were suggested by the Tamil Nadu representative.

i) A canal interlinking the river Kallada and those situated south of it at 500 to 600 ft contour for diversion Eastward through a tunnel at an appropriate location.

ii) A canal interlinking the rivers of Achencoil, Kallada, Vamanapuram and Karamana at an elevation of 250 to 350 ft. around the Southern tip of Western Ghats into Tamil Nadu.

4.4.3 The Tamil Nadu Govt. have sent proposals in respect of alternatives 1 & 2 as already outlined in the foregoing. As regards 3rd alternative, the Tamil Nadu Govt. have indicated that this would result in an unduly long canal resulting in loss of head to a great extent and consequent reduction in the area to be benefited.

4.5 In the sixth meeting of the Committee, the representative of Tamil Nadu was asked to indicate the requirements for Tamil

Nadu for meeting the demands of irrigation. He was requested to supply information regarding details of Command area under irrigation by surface and ground water resources. The required data was supplied by Tamil Nadu and it was noted that they are utilising ground water also where available in these areas.

4.5.1 In the Seventh meeting of the committee the Tamil Nadu representative had explained that the areas lying between elevation 250' to 500' do not have any arrangement for irrigation in the districts of Ramanathapuram and Tirunelveli and these need help most. It was further indicated that this area is estimated to be 4.85 lakh acres. He requested that the surplus from four river basins of Kerala with different alternatives of water requirement may be worked out by the Committee and surplus water, if any, from these basins may be recommended for diversion. He pleaded that the irrigation requirements for the drought prone areas in these districts would be about 80 TMC.

4.5.2 He requested that the assessment of surplus water from Pamba basin of Kerala deferred for the time being may also be taken up later.

5.0 SURPLUS AVAILABLE FOR DIVERSION

5.1 Based on the information discussed in the foregoing chapters, an attempt has been made to work out surplus water availability in the West flowing rivers of Kerala and Karnataka.

In respect of the four river basins of Kerala namely Vamanapuram, Achencoil, Kallada and Karamana, total availability utilisable yield and water requirements for different needs with different alternatives have been worked out.

In respect of the four river basins of Karnataka namely Netravathy, Barapole, Mahadayi and Varahi, the information discussed in para 3 has been made use of for indicating surplus in each basin. Excepting Mahadayi basin, diversions indicated in the State Govt. proposals has been brought out. In respect of Mahadayi, studies regarding the surplus were carried out by the Committee.

5.2 Kerala Basins:

5.2.1 Different alternatives showing calculations of surplus water availability are at Appendix 8 and 9. The alternatives considered are:

5.2.2 Appendix 8 indicates the utilisable yield as arrived at by the other members of the committee, together with the details, regarding the water requirements for various purposes agreed to by the other members of the committee. A delta of 2.61 metre has been adopted for three crops, 50% of garden lands are assumed to be irrigated with the delta of 0.61 metre. The figure of requirements of drinking water, industrial water supply as well as for salinity control are on the basis of the decisions arrived at after discussions in the committee. While the other members of the committee including the Chairman subscribed to this view, the Kerala representative chose to differ. The regeneration contribution has been worked out as 15% of the water requirement of wet lands as agreed to by all the members of the committee. The ground water availability has been assumed at 50% of the value indicated in the report earlier, based on the studies by the C.G.W.B. for the districts of Trivandrum, Quilon and Alleppey.

5.2.3 Another alternative at appendix 9 has been worked out on the lines of the values indicated by the Kerala representative in respect of the utilisable yield as well as the water requirements for the different purposes.

5.3 A study of the alternative worked out on the lines of the recommendation of the other members of the committee given in Appendix 8 have shown that Vamanapuram, Achencoil and Kallada basins have appreciable surplus water. The details are indicated in the following Table 5.3.

Table 5.3

Surplus water in the four basins of Kerala based on utilisable yield and water requirement as per the committee

Basins	Surplus	
	Surplus available (Surface flow only)	Surplus available (Surface + Regeneration + G.Water)
Vamanapuram	+ 9.82 TMC	+ 13.24 TMC
Achencoil	+ 23.63 "	+ 31.25 "
Kallada	+ 13.21 "	+ 20.52 "
Karamana	+ 0.07"	+ 2.58 "
Total:	+ 46.73 TMC	+ 67.59 TMC

(+) Surplus

As has already been discussed in the preceding chapters Pamba basin of Kerala has not been examined and assessment of any surplus in that basin deferred to a later date as per decision of the 7th meeting.

5.4 Karnataka Basins:

Water availability, water requirements etc. in case of Karnataka basins have already been discussed. The surplus water available from the four basins is summarised in Table 5.4.

Table 5.4

Basin	Approx. Yield TMC	Power potential (water need)	Irrigation needs TMC	Quantity available for diversion towards East
Netravathy	35	228 MW (291 TMC)	8.4	24 TMC (11 TMC by gravity 13 TMC by lift 250' to 400')
Barapole	45	180 MW (22 TMC)	-	10.9 TMC
Mahadayi	33	140 MW (11 TMC)	5 TMC	13 TMC*
Varahi	94	239 MW (21.5 TMC)	12.65 TMC	25 TMC*
				72.9 TMC
Total:			Say	73 TMC

* Subject to further studies.

In addition to the above there is possibility of diversion of 5.5 TMC in Aghanashini as indicated by Karnataka. However the committee feels that there is surplus of 25 TMC in Aghanashini and 20 to 25 TMC in Bedthi basins for Eastward diversion. The Committee have already requested Karnataka to conduct studies in this regard.

6.0 RECOMMENDATIONS:

6.1 Surplus water for diversion is available in the Vamanapuram, Achencoil and Kallada basins of Kerala.

6.2 Surplus water for diversion is also available in Netravathy, Barapole and Aghanashini basins of Karnataka. Surplus water assessed in Mahadayi and Varahi could only be confirmed after investigations.

6.3 The extent of surplus in each of above basins is indicated in para 5.3 and 5.4 of the report.

6.4 The examination of the surplus in Pamba basin has not been carried out by the Committee. The water availability, requirements of the basin for different needs may please be carried out by the Kerala Engineers in consultation with Central Water Commission and Tamil Nadu so as to assess surplus water, if any.

6.5 The remaining west flowing rivers of Karnataka where possibilities of diversion of surplus water exist should be studied in detail on a time bound schedule by the Karnataka Engineers in consultation with the Mysore Power Corporation so that irrigation developments can take place in the rain shadow areas of Western Ghats especially in the drought affected districts of Karnataka. Karnataka Irrigation Department should make detailed studies in consultation with Mysore Power Corporation to adjust the tail race levels of the proposed hydel schemes in such a way that these levels could also command some areas for irrigation in the basin.

6.6 The Government of Tamil Nadu may initiate discussions with the Government of Kerala on a bilateral basis for taking up the investigations of projects for the diversion of the surplus waters from the above mentioned basins. The Governments of Tamil Nadu and Karnataka should frame suitable proposals for harnessing the surplus water available for irrigating areas in their drought prone districts to the east of the western ghats. A coordination Committee comprising of members from the States concerned, with, if necessary a member from Centre should be formed to monitor the work of investigation, formulation of reports and working out other details so that benefits from the surplus reach the drought prone areas expeditiously. It is recommended that separate committees are formed for West flowing rivers of Kerala and West flowing rivers of Karnataka.

6.7 The diversion of the surplus waters as suggested above should in the first instance be carried out at such locations wher diversion is possible by gravity.

7.0 ACKNOWLEDGEMENTS:

7.1 The Chairman of the Committee acknowledges with thanks the cooperation extended by the representatives of Government of Kerala, Tamil Nadu and Karnataka for their active participation in the deliberations of the committee. This would have not been possible without their sincere participation and sense of awareness for optimum utilisation of the water wealth of the country. The Chairman of the Committee is also thankful to such other officers of the State Govt. associated with the compilation of the information brought out and discussed in the report.

APPENDIX-1

IST PROPOSAL OF TAMIL NADU

Sl. No.	Name of Basin	Total catchment area in sq.miles	Total runoff in basin in TMC	Surplus in basin TMC	Quantity which can be diverted to east TMC	Ayacut benefited in lakh acres	Districts of Tamil Nadu benefited	
1	2	3	4	5	6	7	8	
	A. Chaliyar Basin							
1.	Pandiyar Punnapuzha Moyar Scheme	1085*	1851*	159.3*	14.0	1.40	Coimbatore	*Pertains to Chaliyar Basin as a whole
2.	Cholathipuzha				3.0	0.3	-do-	
3.	Bangihalla				0.5	0.05	-do-	
	B. Periyar Basin							
4.	Anamalayar				2.5	0.25	-do-	@ Pertains to Periyar basin as a whole
5.	Iddukki	1736@	378@	321.0@	10	1.00	Madurai & Ramnathpuram	
6.	Kallar Diversion dam				2.0	0.20	Madurai	
7.	Pambar	763	222.8	190.5	26.0	2.60	Ramnathpuram and Tiruneveli	
8.	Achencoil	446	76.0	62.9	9.0	0.90	Tiruneveli	
9.	Kallada	600	76.0	43.7				
10.	Vamanapuram	336	52.10	42.2	15.0	1.50	Tiruneveli	
11.	Karamana	250	38.8	28.4				
	Total	5216	1028.9	848.0	82.0	8.2		

Appendix-2

Statement Showing the Water Potential of West Flowing Rivers of Karnataka upto Sea

Sl. No.	Name of the River Basin	Catchment Area		Average Yield in T.M.C.
		Sq. Kms.	Sq.miles	
1	2	3	4	5
1.	Mahadayi River	412	159	33
2.	Kalinadi	4188	1616	256
3.	Bedthi river	3574	1380	178
4.	Independent catchment between Bedthi and Aghanashini Rivers	401	155	32
5.	Aghanashini River	1330	513	108
6.	Sharavathi River	3592	1386	311
7.	Independent catchment of Streams between Sharavathi and Chakra river	1041	402	109
8.	Chakra River	336	130	35
9.	Varahi River	759	293	80
10.	Independent catchment between Varahi and Netravathy river	3067	1186	334
11.	Netravathy River	3222	1244	351
12.	Independent catchment between Netravathy and Barapole river	1320	510	158
13.	Barapole River	560	216	45
	Total:-	23802	9190	2030

Appendix-3

STATEMENT SHOWING THE DETAILS OF HYDRO-ELECTRIC PROJECTS IN KARNATAKA WHICH INVOLVE UTILISATION OF WATER OF WEST-FLOWING RIVERS

Sl. No.	Name of the River	Details of the lower most of Power Dam across the River			Total Utilisation in TMC by the Hydel Schemes across the River	Power Potential		Total Power including existing and proposed in K.Watts.
		F.R.L. in Mtrs.	M.D.D.L. in Mtrs.	Tail Race level in Mtrs.		Existing in K.Watts	Proposed in K.Watts	
1	2	3	4	5	6	7	8	9
1.	Mahadayi River	675.45	644.47	187.76	20.29	-	140,000	140,000
2.	Kalinadi	33.54	27.44	1.52	233.00	-	1298,000	1298,000
3.	Bedthi River	478.54	454.15	88.39	98.36	-	420,000	420.000
4.	Aghanashini River	502.92	472.44	45.72	55.00	-	315,000	315,000
5.	Sharavathi and Chakra Rivers	55.00	45.00	9.00	298.00	1011,000	295,000	1306,000
6.	Varahi River	594.36	566.93	563.88	53.45	-	239,000	239,000
7.	Nethravathi River	79.29	59.44	38.41	291.90	-	228,000	228,000
8.	Barapole River	807.72	777.24	213.36	22.87	-	180,000	180,000
			TOTAL		1072. 87	1011,000	3115,000	4126,000

Appendix-4

WATER AVAILABILITY AND WATER REQUIREMENTS IN 4 BASINS OF KERALA

Sl. No.	Basin	Catchment Area Sq. Km. (sq. Miles)	Estimated Average Yield Mm^3 (TMC)	Utilisable yield Mm^3 (TMC)	Requirement in T.M.C.			
					Irrigation	Domestic & Industrial	Salinity Control	Total
1.	Achencoil	1484 (573)	2287 (80.75)	1249 (44.1)	42.6	2.9	8.1	53.6
2.	Kallada	1919 (740)	2270 (80.16)	1368 (48.31)	41.0	22.7	25.7	89.4
3.	Karmana	702 (271)	836 (29.54)	462 (16.32)	16.0	5.35	5.2	26.55
4.	Vamanapuram	867 (335)	1324 (46.75)	889 (31.39)	26.9	7.6	9.2	43.7

APPENDIX - 5

METHOD OF ASSESSMENT OF WATER AVAILABILITY

1. Vamanapuram Basin:

The assessment of water in the basin at different elevations has been made after establishing rainfall runoff relationship in the form : $R = A + BP$

Details are as under:

Catchment area of the basin = 867 sq.km.

Catchment area:

above 250' contour = 375 sq.km.
50' to 250' contour = 412 sq.km.
below 50' contour = 80 sq.km.

Total: 867 sq.km.

Catchment area up to Valayanki discharge sites = 54 sq.km.

The relation arrived at is $R = 0.91\,P - 459.23$ mm.

Where R = Runoff for entire monsoon period in mm (June to November).

P = Precepitation for the entire monsoon period in mm. (June to November)

C.C.= 0.88 (Co-relation Coefficient)

To arrive at the above equation, the gauge and discharge data for the period 1972 to 1976 have been used. The rainfall data for the corresponding period available at following two stations have been used:

1. Breamore
2. Marchisten

Water Availability:

Based on the above equations the runoff data for the monsoon period for the years 1941 to 1970 has been calculated. To this runoff non-monsoon contribution to the extent of 30.4 percent of monsoon yield has been added to get total yield.

The rainfall data used for computing water availability is as under:-

Raingauge Station	IMD/Private	Period for which Data available
1. Paravoor	IMD	1941 to 69, 71 to 73 (NR)
2. Varkale	IMD	46 to 70
3. Attingal	IMD	41 to 70
4. Nilamel	IMD	46 to 70
5. Breamore	Private	46 to 69
6. Marchisten	-do-	41 to 69
7. Nedumangad	IMD	41 to 70
8. Ponmudi	Private/ IMD	41 to 69

Details of yield based on 75% dependability:

Figures in Mm^3

Elevation	Monsoon	Non-Monsoon	Total
Above 1000' contour	142.00	43.00	185.00
Above 750' contour	172.00	52.50	224.50
Above 500' contour	200.00	61.00	261.00
Above 250' contour	598.00	182.00	780.00
Between 50 & 250' contour	401.00	122.00	523.00
Below 50' contour	5.50	1.50	7.00
		Total:	1310.00 Mm^3

(NR) - Not Recorded

2. Achencoil Basin:

The total catchment area:	1484 sq.km.
Catchment area above 250' contour	673 sq.km.
50' to 250' contour	422 sq.km.
below 50' contour	389 sq.km.
Total:	1484 sq.km.
Catchment area up to Pandalam discharge site	847 sq.km.

Relationship equation $R = 0.53\,P + 370$ mm

R = Runoff for the entire monsoon period in mm (June-November)

P = Precepitation for the entire monsoon period in mm (June-November)

C.C = 0.644 (Co-relation Coefficient)

To arrive at the above equation, the following data has been used:-

Name of raingauge	Name of discharge station
1. Konni	Pandalam
2. Phattanamthitta	
3. Adur	

The relation had been developed based on corresponding rainfall and discharge data for the period 1970 to 1978.

Water Availability:

By utilising the above relation and the monsoon rainfall data for the years 1941 to 1970, runoff for monsoon period for each year has been calculated. To this non-monsoon contribution to the extent of 12.36 percent of monsoon yield has been added to obtain the total yield.

The details of rainfall data used for assessment of water availability is as under:-

Raingauge Station	IMD/Private	Period for the Data available
1. Chengannur	IMD	1941 to 68
2. Haripad	-do-	41 to 70
3. Mavalikera	-do-	41 to 70
4. Kayam Kulum	-do-	41 to 70
5. Konni	-do-	41 to 70
6. Pathanamthitta	-do-	41 to 70
7. Adur		41 to 70

Detail of yield in Mm^3 based on 75% dependability:

(All Figures in Mm^3)

Elevation	Monsoon	Non-Monsoon	Total
Above 250' contour	975	116	1091
Between 50' to 250' contour	534	63	597
Below 50' contour	599	71	670
		Total:	$2358Mm^3$

3. Kallada Basin:

Total Catchment area = 1910 sq.km.

Above 250' contour = 829.00 sq.km.

50' to 250' contour = 608.00 sq.km.

below 50' contour = 473.00 sq.km.

Total: 1910.00 sq.km.

Catchment area up to Enathu discharge site = 1196.6 sq.km.

Relationship equation is R = 0.502P + 84 mm.

Where

R = Runoff for entire monsoon in mm (June to November)

P = Precepitation for the entire monsoon period in mm (June to Nov.)

C.C = 0.84 (Co-relation Coefficient)

The data used for establishing the above relation is as under:-

Raingauge Station	Discharge Station
1. Ponmudi	Enathu discharge site
2. Aryan Kavu	
3. Punlar	

The corresponding rainfall and discharge data for the period 1970 to 1978 (monsoon) has been used.

Water Availability:

Water availability has been assessed by using above equation for the monsoon period. To this figure 14.48 percent of monsoon yield has been added as non-monsoon contribution for obtaining the total yield. The rainfall data used for computing the runoff is as under:-

Raingauge Station	IMD/ Private	Period for the data available
1. Adur	IMD	1941 to 70
2. Ponmudi	-do-	41 to 69
3. Aryankavu	-do-	41 to 70
4. Punaloor	-do-	41 to 70
5. Kottarakara	-do-	41 to 70
6. Konni	-do-	41 to 70
7. Kayamkulam	-do-	41 to 70
8. Karunagapally	-do-	41 to 70
9. Quilon	-do-	41 to 70 (except 61 and 62)

Details of yield in Mm^3 based on 75% dependability:

	Figures in Mm^3		
Elevation	Monsoon	Non-Monsoon	Total
Above 250' contour	1030	149	1179
between 50' & 250' contour	638	92	730
below 50' contour	489	71	560
		Total:	2469 Mm^3

4. Karamana Basin:

Total catchment area:	703 sq.km.
above 250' contour	243 sq.km.
50' to 250' contour	277 sq.km.
below 50' contour	183 sq.km.
Total:	703 sq.km.

Catchment area up to Aryanad discharge station = 155.33 sq.km.

Relationship equation is R = 1.22 P - 1481.78 mm.

Where R = Runoff for entire monsoon period in mm. (June-Nov.)

P = Precepitation for the entire monsoon period in mm (June-Nov.)

C.C = 0.90 (Co-relation Coefficient)

The data used for establishing the above relation is as under:

Name of the rainfall Station	Name of discharge Station
1. Bonocard	Aryanad
2. Nadumangad	

The corresponding data of rainfall and discharge for the monsoon period 1971 to 1978 has been utilised for establishing the above relationship.

Water Availability:

The monsoon runoff has been calculated by utilising the above relationship. 19.76 percent of monsoon yield has been added as contribution of non-monsoon yield to arrive at total yield. The annual yield has been computed by utilising the following data:

Raingauge Station	IMD/ Private	Period for the data available
1. Ponmudi	IMD/ Private	1947 to 1978
2. Bonacard	Private	1947 to 1978
3. Nedumangad	IMD	1947 to 1978
4. Neyatinkara	IMD	1947 to 1978
5. Trivandrum	IMD	1947 to 1978 (except 1970)

Details of yield in Mm^3 based on 75% dependability:

Figures in Mm^3

Elevation	Monsoon	Non-monsoon	Total
above 250' contour	447	88	535
between 50' & 250' contour	18	6.00	34
below 50' contour	56	11	67
		Total:	636 Mm^3

APPENDIX - 6

KERALA BASINS

SALINITY REQUIREMENTS

All figures in Mm^3

Sl. No.	Name of Basin	As per Kerala Report	As per Kerala Report of 1974
1.	Vamanapuram	261	87
2.	Achencoil	420	N.A.
3.	Kallada	729	642
4.	Karamana	148	148

N.A. - Not Available

APPENDIX - 7

STUDY ON MAHADAYI BASIN OF KARNATAKA

1. Introduction:

Belgaum, Chitradurga, Baijapur, Dharwar districts of Karnataka are located on leeward side of Western Ghats and get very scanty rainfall and are affected frequently due to drought Some areas in these districts are irrigated by canal system fed from Ghataprabha and Malaprabha reservoirs. However, some of the areas lying between 650 and 600 M. do not get irrigation supply.

1.1 Present study explains the possibility of diverting part of surplus water from Mahadayi basin into Malaprabha basin to irrigate drought-prone areas situated in Belgaum district.

2. Mahadayi river originates from Western Ghats in Karnataka and flows towards west for 35 km through Karnataka before entering Goa and it then falls into Arabian sea.

2.2 Catchment area of the basin is 412 sq.km. (159 sq.miles) and is mostly hilly and steep. Karnataka Government has assessed the average yield of the basin as 33 TMC (934 Mm^3). State Government is not collecting gauge and discharge data of this river. So this is not possible to establish rainfall run-off relationship for this basin.

2.3 State Government has worked out yield of the basin as 33 TMC based on Inglis formula and has been used for this preliminary study.

3. Hydel Generation Proposals of State Govt. (Mysore Power Corporation)

3.1 The present proposal of Karnataka envisage the construction of main storage dam at Kangla and subsidiary dam at Kothi across Mahadayi river. Forebay at Kothi dam has been provided to feed water conductor system and power house. Water conductor system taking off from the fore bay comprises of 5 miles/8.5 km. long tunnel, surge tank, pen-stocks and tail race. Salient features of the scheme are indicated in Exhibit 7.1. It is proposed to instal 2 units of 70 MW each and average head available is 487.67 M (1600 ft.) and estimated power draft is reported as 17.84 cumecs/ 630 cusecs.

3.2 Catchment area at Kangla dam site is reported to be as 88.58 sq.km. and yield is assessed as 430 Mm^3/15.2 TMC. FRL is proposed at elevation 675.45 M and MDDL at 664.47 M. Gross capacity of the reservoir is estimated as 470 Mm^3 against net capacity of 202.01 Mm^3.

3.2.1 Water will flow from Kangla dam to Kothi dam located downstream of Kangla Dam. Catchment area of Kothi Dam (independent) is reported as 16.52 sq.km. FRL at Kothi dam is kept at elevation 611.44 M (2006 ft.). It is proposed to carry the water by 8.5 km. long tunnel to power house to generate hydel power at 1600 ft. average head and 17.84 cumecs/630 cusecs power draft. 2 units of 70 MW each are proposed to be installed for generation of power.

3.3 Study of the plan shows that Kothi dam does not take into account the water inflow from Chanda Nalla which flows into Mahadayi downstream of Kothi dam. Independent catchment area including Chanda Nalla is about 69 sq.km. (26.9 sq.miles).

3.4 State Government has not reported any irrigation from this basin. This is presumably, due to the reason that area is hilly and has steep slopes. It appears that rainfed cultivation may be possible in this area. Alternatively, it may be possible to irrigate some area by lift irrigation which is estimated to be not more than 5000 ha. (approximately). Water required for cultivation of paddy 3 crops assuming delta as 2.7 M comes to 135 Mm^3.

3.4.1 Present and future population figures in this basin are not supplied by the State Government. As per 1961 census, the average population in Karnataka was 123 persons per sq.km. and as per the 1971 census, the average population of the State is 153 persons per sq.km. Assuming the population density to be on the safe side, as 300 persons per sq.km., total population of the basin could be 1,23,000. As there is no major city in the area, 50% of the population could be assumed in rural areas and 50% in urban areas. The needs of rural population can be met out of ground water. Annual requirement of urban population assuming 160 litre per head per day comes to 3.65 Mm^3.

3.4.2 State Government has not indicated the present industries located in the basin and future industries expected to be located in this area. However, part of the tail race water from power schemes can be used for industrial requirements. The balance requirements, if any, can be met out of ground water resources.

3.4.3 Problem of salinity in this basin is not anticipated. However, tail race water will flow constantly and is likely to solve the future problem of salinity, if any.

3.5 Thus, the annual water requirement of State Government in this basin could be as below:

i)	Generation of Hydel Power:	
	a) Live storage:	202.01 Mm^3
	b) Additional water during monsoon:	101.00 Mm^3
ii)	Irrigation:	135.00 Mm^3
iii)	Domestic & Industrial:	3.65 Mm^3
	Total:	441.66 Mm^3
	Say:	442.00 Mm^3

3.6 The average yield as worked out by the Karnataka Government for this basin is 33 TMC which comes to 934 Mm^3. Yield up to Kangla dam from catchment area of 88.58 sq.km. is assessed as 15.2 TMC i.e., 430 Mm^3. Yield on proportionate basis from Kangla to Kothi dam could be 80.19 Mm^3. Thus, the total yield up to Kothi dam on probable basis is estimated as 510 Mm^3, which shows a surplus of about 70 Mm^3.

4. Alternate Proposal:

4.1 Kangla Dam: It is proposed that Kangla dam should be constructed at a site as proposed by Karnataka. However, FRL may be raised, if technically feasible, so as to provide additional storage of water.

4.2 Kothi dam should not be constructed and a dam below the confluence of Chanda Nalla should be constructed with FRL at 611.44 (2006 ft.). (Same as that at Kothi dam). Catchment area between Kangla dam and Chanda dam is estimated as 85 sq.km.

Assuming the yield for Chanda dam on proportionate basis as that of Kangla dam it comes to:

$\frac{430}{88.58}$ 412 Mm^3

Assuming 90% of this, the available yield for hydel generation etc. could be 371 Mm^3. Hence the alternative Chanda dam can safely meet most of the requirements of hydel generation and irrigation and other uses. However, this can be supplemented by supplies from Kangla dam. The length of the tunnel for carrying water for hydel generation comes to 2350 M against 10,000 M as proposed by State Govt.

4.3 Total requirement as estimated in para 3.5 comes to 442 Mm^3 against the total available 801 Mm^3 (430 + 371 = 801 Mm^3) at Chanda dam and Kangla dam sites. In view of the above, surplus water available is of the order of about 801 - 442 = 359 say 360 Mm^3 (12.7 TMC).

5. Irrigation in Districts of Belgaum, Dharwar etc.:

Topo sheets study indicates that areas below elevation 660 M. comes to 1515 sq.km. (excluding areas irrigated and submerged in Malaprabha basin).

Assuming 75% of the area as GCA this is estimated to be 1136 sq.km. CCA is (assuming 70% of the GCA) 795 sq.km. say, 800 sq.km. = 80,000 hectares.

5.1 Assuming dry crops in this area for irrigation, taking into consideration the shortage of water.

i) 50% of the area under oil seeds/Sorghum/Bajra.

ii) 50% of the area under groundnut/maize (taking delta of 0.15 M for item (i) and 0.30 for item (ii)).

5.2 Total water requirement is estimated as 180 Mm^3

Add 30% for losses = 54 Mm^3

Thus total water required is estimated as 234 Mm^3 against surplus available 360 Mm^3.

It is possible to divert the required amount of water from Kangla dam which has a gross storage capacity of 470 Mm^3 and yield of 430 Mm^3. Surplus water can be used for generation of power and to meet the additional demand of irrigation if any, in the basin.

6. These studies are based on preliminary data supplied by the Karnataka Government.

6.1 It may thus be seen that Karnataka will be able to instal 2 units of 70 MW each and irrigate 5000 ha. in Mahadayi basin, and part of surplus water after diversion to East can meet the demand of dry irrigation in an area of 80,000 ha. located in Karnataka.

In view of the above, the proposal requires detailed investigations by the State Government for framing the proper scheme.

7. It is suggested that similar studies for each basin should be made by Karnataka Government to assess the surplus water available, if any, for each basin.